Name of subject	Electric machines (ECTS 12)
Subject/module code	EM14512
Science taught semester (s).	$4^{th}/5^{th}$ semesters
Responsible teacher	Saodullayev Abror Saypullayevich
Education language	Uzbek
Study to the program connection	Compulsory
Training hours (this including independent education)	**Total hours-360.** **Audience Training hours - 144.** Lecture training hour – 72 Laboratory training hour –24 Practical training hour – 48 **Independent education -216 hours**
ECTS	12
The purpose and tasks of subject / learning outcomes	**The purpose of teaching this subject:** The aim of the course is to teach students the structure and principles of operation of electric machines, their selection, operation, analysis of the physical processes occurring in them, calculation of the energy efficiency of electric machines, and formation and development of the design thinking of electric machines, teaching them to clearly state their opinions and conclusions in a well-founded manner, and to develop the skills to apply them in practice. **The task of the subject** is to teach students how to construct switching circuits for electric machines and determine their parameters, calculate and analyze the characteristics of electric machines, evaluate various operating modes of electric machines, control electric machines and adjust their speeds; design electric machines, and teach them the basic criteria for increasing and ensuring the efficiency of electric machines. **Learning outcomes:** 1. The student will study the nature of electromechanical phenomena in nature and technology of electric machines through the fundamental concepts of the science of electric machines. 2. The student will study the structure, operating principle, applications and characteristics of transformers. 3. The student will study the structure, operating principle, applications and characteristics of alternating current machines. 4. The student will study the structure, operating principle, applications and characteristics of direct current machines.
Course content (topics)	**I. Main theoretical part (Lecture)** **Topic 1:** Introduction to the science of "Electrical machines". Physical processes occurring in transformers. **Topic 2:** Magnetic cores of transformers and the structure of magnetic cores. Electromagnetic processes occurring in no-load and short-circuit modes of the transformer. **Topic 3:** EMF and currents in transformer windings. Conversion of the electrical parameters of the secondary winding of the transformer to the number of primary winding windings. **Topic 4:** T-shaped switching schemes and vector diagrams of the transformer. **Topic 5:** External characteristics of transformers. Voltage adjustment. **Topic 6:** Connection groups of transformer windings. Conditions for parallel connection.

Topic 7: Parts and schemes of the stator winding of alternating current machines.

Topic 8: Magnetic Motive Forces (MMF) and Magnetic Fields. Pulsating, elliptical, and circular rotating magnetic fields

Topic 9: Types of induction machines, their structure and operating principle. Topic 10: Operating modes of an induction machine.

Topic 11: Electromagnetic processes occurring in an induction machine with a braked rotor.

Topic 12: Conversion of rotor winding parameters to the number of stator winding windings

Topic 13: Obtaining experiments on the operation of induction motors and short circuits.

Topic 14: Vector diagrams of an induction machine

Topic 15: Energy diagram of an induction machine

Topic 16: Electromagnetic (rotating) torque and mechanical characteristics of an induction machine

Topic 17: Operating characteristics of an induction motor. Starting an induction motor.

Topic 18: Adjusting the frequency of rotation of an induction motor.

Topic 19: Induction generator, electromagnetic processes and characteristics in it.

Topic 20: Modern series and special types of induction machines. Induction frequency converter.

Topic 21: Types of synchronous generators, structure and operating principle of synchronous machines.

Topic 22: Types of excitation of synchronous generators.

Topic 23: Armature reaction.

Topic 24: Equations and vector diagrams of permanent and non-permanent pole synchronous generators.

Topic 25: Parallel connection of a synchronous machine to an electrical network. Synchronization methods.

Topic 26: Characteristics of a synchronous generator in parallel operation with an electrical network.

Topic 27: Angular characteristic of the reactive power of a synchronous machine.

Topic 28: Structure and operating principle of a synchronous motor.

Topic 29: Operating characteristics of a synchronous motor.

Topic 30: Operating characteristics of a small-power and linear synchronous motor at various loads.

Topic 31: Power losses and useful work coefficient in a synchronous machine.

Topic 32: AC machine. The structure of DC machines and the principle of operation as generators.

Topic 33: Characteristics of DC generators

Topic 34: The structure of DC motors and physical processes in motors.

Topic 35: Starting DC motors

Topic 36: Methods of adjusting the speed of DC motors

II. Instructions and recommendations for organizing laboratory exercises.

The department develops methodological instructions and recommendations for organizing laboratory exercises. In them, students will further enrich the knowledge and skills they have acquired on the topics of the main lectures and practical exercises by performing

laboratory exercises and performing relevant calculations.

Suggested topics for laboratory work:

1.Conducting experiments with single-phase toroidal transformers and Scott transformers.

2.Experiments with a single-phase autotransformer.

3.Conducting experiments with a three-phase transformer. Checking the characteristics and parameters of a three-phase two-winding transformer in the conditions of continuous operation and short circuit. Determining the connection groups of three-phase two-winding transformers.

4.Conducting experiments with a 400/690 V short-circuited asynchronous motor. Conducting experiments with a 230/400 V short-circuited asynchronous motor. Checking the continuous operation and short-circuit characteristics of a three-phase squirrel-cage rotor asynchronous motor and determining its parameters. Checking the operating characteristics of a three-phase squirrel-cage rotor asynchronous motor.

5.Conducting an experiment with a capacitor F electric motor.

6.Checking the characteristics of the synchronous generator for single-phase operation and load. Checking the external and adjustment characteristics of the synchronous generator.

7.Checking the characteristics of the synchronous generator in parallel with the electrical network and the V-shaped characteristics.

8.Conducting an experiment with a universal electric motor. Checking the operating characteristics of a three-phase synchronous motor.

9.Conducting an experiment with shunt-parallel excitation machines. Checking the condition of an independent excitation DC generator with an armature rotation speed of n=nn=const.

10.Experiment with step-by-step machines. Checking the details of adjustment, external and short-circuit.

11.Checking linear DC motors.

12.Checking a mixed-excitation DC motor.

III. Instructions and recommendations for practical training

The department will develop instructions and recommendations for organizing practical training. In it, students will further enrich the knowledge and skills they have acquired on the main lecture topics through practical problems and cases. It is also recommended to consolidate students' knowledge based on textbooks and manuals, use handouts, increase students' knowledge by publishing scientific articles and theses, solve problems, prepare presentations and visual aids on topics, use regulatory legal documents, etc.

Recommended practice topics:

1.Determination of the main parameters of a single-phase toroidal transformer;

2.Determination of the connection group of single- and three-phase transformer windings;

3.Determination of the parameters of single-phase toroidal and Scott transformers for short-circuit and short-circuit operation;

4.Determination of the voltage drop of a transformer operating with a load. Determination of the parameters of autotransformers.

5.Calculation of the useful efficiency of the transformer depending

on its power;

6.Checking the conditions for parallel connection of transformers;

7.Starting an asynchronous motor using additional resistance;

8.Determination of the parameters of a repulsion electric motor;

9.Solving problems related to methods for adjusting the rotation frequency of an asynchronous motor;

10.Determination of the parameters of capacitor electric motors;

11.Calculation of the capacities of the working and starting capacitors for connecting a three-phase asynchronous motor to a single-phase network;

12.Calculation of the parameters of short-circuit motors with an alander chain;

13.Construction of the adjustment characteristic of a synchronous generator;

14.Construction of the external characteristic of a synchronous generator;

15.Construction of the U-shaped characteristic of a synchronous generator;

16.Construction of the angular characteristic of a synchronous generator;

17.Construction of the U-shaped characteristic of a synchronous motor;

18.Calculation of power losses in DC machines;

19.Calculation of the parameters of multifunctional DC motors;

20.Determination of the main parameters of an DC motor;

21.External characteristic of DC generators;

22.Calculation of the mechanical characteristics of an DC motor;

23.Solving problems related to methods for adjusting the rotation frequency of an DC motor;

24.Calculation of the parameters of shunt-parallel-excited DC motors.

IV. Instructions and recommendations for the course project

The course project develops the skills of creative independent work, forms in students the skills of performing electromagnetic and thermal calculations of transformers and asynchronous motors. Each student is given an individual assignment. The topics of the course project are regularly reviewed and approved.

Sample topics of the course project

1. Perform electromagnetic and thermal calculations of a three-phase two-winding transformer with a total capacity of (…) kVA, high and low voltage values (…) V, connection scheme and group (….);

2. Perform electromagnetic and thermal calculations of a three-phase two-winding transformer with a total capacity of (…) kVA, high and low voltage values (…) V, connection scheme and group (….);

V.Independent learning and independent work.

Independent learning competence serves to support students' independent self-development and increase the effectiveness of professional activities. Students perform independent work on their mobile devices under the guidance of a teacher in a traditional or electronic form.

Independent study for the recommended topics:

1.Transformers by operating modes.

	2.Types of special transformers. 3.General issues of alternating current machines. 4.Special asynchronous machines. 5.Special synchronous machines. 6.Special direct current machines. 7.Calculation of the main parameters of the transformer based on experimental data. 8.Construction of a characteristic of the transformer in the case of sudden and short-circuit operation; 9.Construction of an external and adjusting characteristic of the transformer; 10.Calculation of the useful efficiency of the transformer depending on its power; 11.Checking the conditions for parallel connection of transformers; 12.Starting an asynchronous motor using additional resistance; 13.Determination of the operating characteristics of an asynchronous motor using a circular diagram of currents; 14.Accurate calculation of the mechanical characteristics of an asynchronous motor; 15.Calculation of the working and starting capacitor capacities for connecting a three-phase asynchronous motor to a single-phase network; 16.Construction of the Potye diagram of a synchronous generator; 17.Construction of the adjustment characteristic of a synchronous generator; 18.Calculation of power losses in AC machines; 19.Switching in AC machines; 20.Determination of the main parameters of an AC motor;
Student assessment	Assessment of student knowledge is based on the mastery of the teaching material during the semester and final control (tests, assignments, written and oral work results). During the course of Electrical Machines, students are evaluated on a 100-point system. Of these, 50 points are allocated to the current and intermediate results (60% of the 50 points are current control, independent study and 40% are intermediate control), and 50 points are allocated to the final control results. Students whose total score of current and intermediate points is less than 30 points are not admitted to the final control exam. A student who scores 30 or more points in the final control is considered to have mastered the subject.
Requirements for exams	The student must have fully mastered the theoretical and practical concepts of the subject, be able to correctly reflect the results of the analysis. The student must have completed the tasks given in the current and intermediate forms of independent work, assessment. At the same time, he must have received the necessary points from the current, intermediate, independent education and final tests in the relevant subject within the specified time. A student who has not submitted current control, intermediate control and independent education tasks, as well as who has scored less than 30 points on these tasks and types of control, will not be included in the final type of control. Also, a student who has missed 25 or more percent of the classroom hours allocated to the subject without an excuse will be expelled from this subject, will not be allowed to take the final exam and will be considered as not having mastered the relevant credits in this subject. A student who fails the final exam or scores less than 30 points on this type of exam is considered academically indebted.
Recommended Literature	**Main literature:** 1.Salimov J.S., Pirmatov N.B. Elektr mashinalari.– T.:

O’zbekiston faylasuflari milliy jamiyati nashiryoti, 2011. –408 b.

2.Mustafakulova G.N., Toirov O.Z., Bekishev A.E. Elektr mashinalari. Toshkent.: Tafakkur avlodi. 2020. 191 b.

3.Majidov S. Elektr mashinalari va elektr yuritma. - T.: O’qituvchi, 2002. -358 b.

4.S. K. Sahdev/Electrical Machines/ © Cambridge University Press 2018

5.Testing of Power Transformers under participation of ° Carlson Ake Jitka Fuhr Gottfried Schemel Franz Wegscheider 1st Edition published by Pro Print GmbH, Düsseldorf ISBN 3-00-010400-3-2003.

6.Alimxodjayev K.T., Pirmatov N.B., Ziyoxodjayev T.I. Elektr mashinalari.- T.: “Fan va texnologiya”, 2018. -344 b.

7.Alimxodjayev K.T., Pirmatov N.B., Ziyoxodjayev T.I., Mustafakulova G.N. Elektr mashinalari va transformatorlarning ekspluatatsiyasi. - T.: “Fan va texnologiya”, 2019. -240 b.

8.Копылова И.П. Электрические машины: Учебник для бакалавр – Москва:. Юрайт, 2012. – 675 с.

9.Иванов – Смоленский А.В. Электрические машины. В 2-х т. Учебник для вузов.– М.: Изд–воМЭИ, 2004. Том. 1 – 652 с, Том 2 – 532 с.

10.Salimov J.S., Pirmatov N.B., Bekchanov B.E. Transformatorlar va avtotransformatorlar. T.: “VEKTOR-PRESS”, 2010.-224 b.

11.N.B.Pirmatov, A.S.Saodullayev, A.Y.Bekishev, N.A.Qurbonov «Elektr mashinalari» o’quv qo’llanma O’zbekiston Respublikasi Oliy va o’rta-maxsus ta’lim vazirligi. – Toshkent: «ZEBO PRINT» nashriyoti. 2022.-197 b.

12.A.Saodullayev, U.Mirzayev «Elektr mashinalari fanidan tajriba mashg’ulotlarini bajarishga oid uslubiy ko’rsatma» Jizzax-2022. JizPI nashriyoti, 60 b.

Additional literature:

13.Mirziyoyev Sh.M. Erkin va farovon, demokratik O‘zbekiston davlatini birgalikda barpo etamiz. O‘zbekiston Respublikasi Prezidentining lavozimiga kirishish tantanali marosimiga bag‘ishlangan Oliy Majlis palatalarining qo‘shma majlisidagi nutqi. – T.: “O‘zbekiston” NMIU, 2016. – 56 b.

14.Mirziyoyev Sh.M. Qonun ustuvorligi va inson manfaatlarini ta’minlash – yurt taraqqiyoti va xalq farovonligining garovi. O‘zbekiston Respublikasi Konstitusiyasi qabul qilinganining 24 yilligiga bag‘ishlangan tantanali marosimdagi ma’ruza 2016 yil 7 dekabr. – T.: “O‘zbekiston” NMIU, 2016. – 48 b.

15.Mirziyoyev Sh.M. Buyuk kelajagimizni mard va olijanob xalqimiz bilan birga quramiz. – T.: “O‘zbekiston” NMIU, 2017. – 488 b.

16.O‘zbekiston Respublikasini yanada rivojlantirish bo‘yicha Harakatlar strategiyasi to‘g‘risida. – T.:2017 yil 7 fevral, PF-4947-sonli Farmoni.

17.Pirmatov N.B., Yarmuxamyedova Z.A., Mustafakulova G.N. Elyektr mashinalari fanining transformatorlar qismi bo‘yicha kurs loyihasini bajarishga oid o‘quv-myetodik qo‘llanma. –T.: ToshDTU, 2012 – 117 b.

18.Кацман М.М. Сборник задач по электрическим машинам. Учеб. Пособие для вузов. –Москва.: – Издательский центр «Академия». 2012. –154 с.

19.Mustafakulova G.N., Toshev Sh.E. Elektr mashinalari fanidan laboratoriya mashg‘ulotlarini bajarish uchun metodik ko‘rsatma. –T.: TDTU, 2015. – 45 b.

20.Pirmatov N.B., Zayniyeva O.E. Elektromexanika (Elektr mashinalari) fanidan masalalar to‘plami. O‘quv qo‘llanma. –T.: TDTU, 2004. – 75 b.

Internet resources:

21.www.ziyonet.uz
22.http://dhes.ime.mrsu.ru/studies/tot/tot_lit.htm;
23.http://rbip.bookchamber.ru/description.aspx?product_no=854;
24.http://energy-mgn.nm.ru/progr36.htm